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#2958

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J. Lamb / 1034A

Requestor — Document Center (is requested to provide the following document)

Date of request ~~3/16/96~~ 3/29/96 — Expected receipt of document ~~3/1?/96~~ 4/30/96

Document number K2-2699 — Date of document 3/1/46

Title and author (if document is unnumbered)

(This section to be completed by Document Center)

Date request received 4/8/96

Date submitted to ADC 4/15/96

Date submitted to HSA Coordinator 4/8/96

(This section to be completed by HSA Coordinator)

Date submitted to CICO 4/15/96 5/7/96

Date received from CICO 5/8/96

Date submitted to ChemRisk/Shonka and DOE 5/14/96

(This section to be completed by ChemRisk/Shonka Research Associates, Inc.)

Date document received

Signature

#2958

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS CORP. LOCATION Post Office Box P OAK RIDGE, TENN.

REPORT NO. KZ 2699

TO LOCATION Mr. A. M. Squires

DATE March 1, 1946

ANSWERING LETTER DATE

ATTENTION

SUBJECT U_{234} Performance

COPY TO

Mr. C. N. Rucker
Mr. P. L. Alspaugh
Dr. D. E. Hull
Dr. F. W. Hurd
Dr. D. A. MacRae
Mr. J. A. Klassmann
Dr. R. L. Macklin

FILE 963B
X-REF.
X-REF.

[redacted]

Classification changed to: UNCLASSIFIED (level and category)

4/30/96
ADD or ADO signature (first reviewer) Date

5/1/96
ADD signature (final reviewer) Date

Dear Mr. Squires:

The suggestion that the performance of a building be measured for U_{234} has been passed along for investigation. The use of alpha counting for this purpose seems entirely feasible. Calculation of the equivalent U_{235} performance from that of U_{234} was not included in this investigation but a preliminary survey has not shown any fundamental difficulties provided complete recycle can be assumed.

A method of calculating the ratio of the weight fractions of U_{234} at two points such as the top and bottom of an isolated building is developed with particular attention to minimizing the error.

(0.0-2.3) 4% material will give smaller errors than any other. The reason may be roughly outlined as due to two factors in alpha counting. The higher the proportion of U_{234}, the greater its contribution to the total alpha count and hence the more closely the alpha count will determine the proportion of U_{234}. On the other hand the higher the proportion of U_{234} the greater the alpha counting rate will be. As the preparation of U_3O_8 films is restricted fairly closely to films from one to ten milligrams, the higher counting rates cannot be cut down by using lighter films. As the uncertainty in the correction for resolving time of the alpha counters is about ten percent, the magnitude of the correction must be kept low. Data obtained from Mr. Klassmann shows that an enrichment of U_{234} greater than five or six, makes this correction error greater than the uncertainty in counting rate.

The alpha counting calculations and error estimates follow. To minimize instrument fluctuations samples should be rotated and several films, differing in weight used for each sample. By this means the self absorption and resolving time corrections can be determined for each sample individually. The alpha counting rates thus obtained (by extrapolation of the rates on the several films for each sample) are hereinafter designated by A and are expressed in counts per minute per milligram of U_3O_8 film.

The counting rate A of each sample is composed of three parts representing the contribution of the three uranium isotopes.

$$A = A_{234}\ x_{234} + A_{235}\ x_{235} + A_{238}\ x_{238}$$

This document has been approved for release to the public by: Technical Information Officer, Oak Ridge K-25 Site 5/7/96 Date

[redacted]

Carbide and Carbon Chemicals Corporation, Operating Contractor for the U.S. Atomic Energy Commission.

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(m represents the weight of oxide of each isotope in milligrams present in each milligram of U_3O_8 film)

The counting rates of each isotope (A_{234} A_{235} and A_{238}) can be calculated for normal (feed) uranium from the measured isotope ratios and the relative activities of U_{235} and U_{238}.

$$n^o_{234} = 0.000059 \qquad n^o_{235} = 0.00714 \qquad n^o_{238} = 0.9928$$

*The relative activities of U_{235} and U_{238} in nature are stated to be as 0.046 to 1.

*Nier - Phys. Rev. 55, 150 (1939)

The International Table of Stable Isotopes for 1938 gives the isotopic weights as 235.084 and 238.088. Assuming a weight of 234.0 for U_{234} the weight fractions in natural urnaium are then

$$m^o_{234} = 0.000058 \qquad m^o_{235} = 0.00705 \qquad m^o_{238} = 0.9929$$

The activity of U_{234} and U_{238} in natural uranium is equal because of their radioactive equilibrium. Thus the fraction of the alpha activity due to each isotope will be

$$\frac{1}{1 + 1 + 0.046} = 0.4888 \quad \text{for} \quad U_{234}$$

$$\frac{0.046}{1 + 1 + 0.046} = 0.0225 \quad \text{for} \quad U_{235}$$

$$\frac{1}{1 + 1 + 0.046} = 0.4888 \quad \text{for} \quad U_{238}$$

and

$$A_{234} = \frac{0.4888}{0.000058} A^o = 8430 A^o$$

$$A_{235} = \frac{0.0225}{0.00705} A^o = 3.19 A^o$$

[redacted]

$$A_{238} = \frac{0.4888}{0.9929} A^o = 0.49224 A^o$$

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The value of A^0 is to be determined by measuring a set of normal U_3O_8 films in rotation with the test samples to eliminate the effect of any change in the instrument used.

The weight fraction of U_{235} in the test films (m_{235}) can be determined to a fair degree of accuracy (i.e. 1%). As a first approximation the weight fraction of U_{238} can be considered the entire remainder of the uranium. The first approximation (m_{234}^{1}) of m_{234} is then:

$$m_{234}^{1} = \frac{1}{8430A^0}\left[A - 3.19A^0\, m_{235} - 0.49224A^0\,(1 - m_{235})\right]$$

or

$$m_{234}^{1} = \frac{1}{8430}\left[\frac{A}{A^0} - 2.698\, m_{235} - 0.49224\right]$$

Successive approximations are obtained by correcting the mass of U_{238} for U_{234}.

$$m_{234}^{11} = \frac{1}{8430}\left[\frac{A}{A^0} - 2.698\, m_{235} - 0.49224\,(1 - m_{234}^{1})\right]$$

$$m_{234}^{111} = \frac{1}{8430}\left[\frac{A}{A^0} - 2.698\, m_{235} - 0.49224\,(1 - m_{234}^{11})\right]$$

$$\frac{m_{234}^{11} - m_{234}^{1}}{m_{234}^{1}} = \frac{.49224}{8430} = .000058 \quad \text{or} \quad 0.006\%$$

$$\frac{m_{234}^{111} - m_{234}^{11}}{m_{234}^{1}} = \frac{.49224}{8430}\,(.000058) \cong 3 \times 10^{-9}$$

The second approximation adds but six thousandths of a percent to the value of m_{234} and succeeding approximations each the same fraction of the preceding correction. As instrument errors will certainly be of the order of one tenth of a percent or more there is no gain in taking more than the second approximation. The value of m_{234} is therefore considered sufficiently well expressed by m_{234}^{11}.

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The change in the value of m_{234} resulting from a 1% increase in m_{235} (from fission count) is

$$-\frac{2.7}{8430}(0.01\ m_{235}) = -\ 0.0000032\ m_{235}$$

This represents a change of 0.039% in m_{234} for feed material. For top plant product the percentage change in m_{234} would be about 0.06% and at other points in the plant it should not exceed 0.05%. (These values for plant material are based on alpha counting experience with the "Sternberg Specials").

Errors in m_{234} due to errors in the isotope ratios for normal almost completely cancel out in taking the ratio for two test samples differing in concentration by no more than the separation factor of a single building. Reasonable errors in A^o (say 1%) likewise cancel almost completely in the ratio.

The alpha counting errors contribute to the error in the U_{234} enrichment ratio in different degrees depending on the concentration. For top plant material a 0.10% change in the counting rate (A) of one of the test samples gives a change of 0.10% in the ratio. For feed material however, an equal change (0.10%) in A gives [illegible] change in the enrichment ratio. For material enriched 5.6 times (~4% U_{235}) a [illegible]nge in A gives a change of 0.12% in the enrichment ratio. At this enrich[illegible] the [illegible]nting rate of the heaviest films (10 mg) is 21,000 counts per [illegible] line extrapolation of alpha counter results is not deemed valid [illegible] above this.

[illegible] for the test samples (top and bottom of the isolated building) [illegible]low 0.50% can reasonably be expected. The corresponding [illegible]nt of U_{234} is below one percent. Longer than normal [illegible]led statistical analysis might improve the estimated

R L Macklin

R. L. Macklin

Approved: Frank W Hurd

[redacted]

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